stat teaser

ABOUT STAT-EASE SOFTWARE, TRAINING, AND CONSULTING FOR DOE
Phone 612.378.9449 Toll-Free 800.801.7191 E-mail info@statease.com Web Site www.statease.com

Workshop Schedule

Experiment Design Made Easy
October 24–26: Philadelphia, PA
November 7–9: San Jose, CA **(New!)**
December 5–7: Anaheim, CA

Study the practical aspects of Design of Experiments (DOE). Learn about simple, but powerful, two-level factorial designs.

Response Surface Methods for Process Optimization
November 7–9: Atlanta, GA
March 6–8, 2001: Philadelphia, PA

Find the optimum settings for your process. Generate 3D maps to identify peak areas and overlay plots to find your sweet spot.

Mixture Design for Optimal Formulations
September 19–21: Philadelphia, PA
November 14–16: Minneapolis, MN

Standard factorial designs don't work well for formulations. Learn all the skills you need for mixture design in this course.

Robust Design: DOE Tools for Reducing Variation
October 3–5: Minneapolis, MN
June 5–7, 2001: Philadelphia, PA

Use DOE to create products and processes that are robust to varying conditions. Factorial and RSM proficiency is required.

DOE Simplified (New!)
November 29: Dallas, TX
November 30: Atlanta, GA

This one-day workshop offers an introduction to DOE. It provides an overview of DOE concepts and illustrates an array of tools and design types. Attendees receive a free copy of the book, *DOE Simplified*, which comes with a time-limited copy of Design-Ease® 6 software.

Attendance limited to 20. Reserve your place by calling Sherry, x18, at **800.801.7191.**

Stat-Ease® statistics made easy™

Put a Spring in Your Step

Half a century ago, Richard James worked on springs to keep sensitive instruments steady at sea. One day this naval engineer accidentally knocked an experimental coiled spring off a table onto a pile of books. It tumbled each step of the way in a delightful walking motion. James made the coil into a toy called the Slinky™, which became an instant success.

Like most baby-boomers, I participated in the original Slinky craze. Several years ago, a scene in "Ace Ventura - When Nature Calls" awakened my interest in the Slinky, which in the movie walks down an impossibly huge number of steps on a gigantic Himalayan stairway. (You have to rent the video and be a Jim Carrey fan to appreciate the humor!) The most obvious factor affecting the Slinky's walking ability is the degree of incline, which according to experts must be between 20 and 40 degrees. If the incline is too shallow, the coil will not move. Too steep an incline causes the coil to tumble or roll out of control.

After spending this much time learning about the Slinky, I couldn't resist digging through the toy chest and dragging out several spring toys (see picture). My daughter Katie, age 9 at the time, was appointed as research assistant. I set up a board to verify the data on the incline. After observing slippage on the bare wood, I added a

high-friction rubber mat for the walking surface (seen in the picture).

I chose three coiled spring toys (two with the Slinky brand and one generic) to test at two inclines in a full-factorial experiment. We replicated each of the six combinations (3x2) in a completely randomized

- cont. on page 2

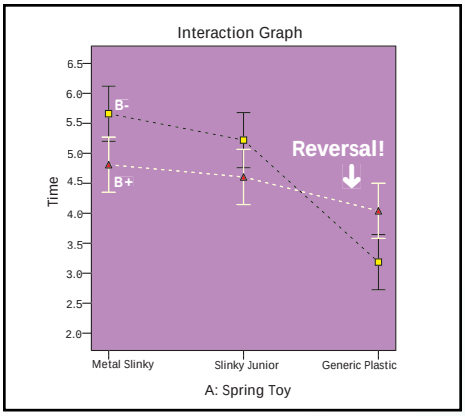
Std	A:Spring Toy	B:Incline	Time (sec)
1, 2	Metal Slinky	Shallow	5.57, 5.75
3, 4	Slinky Junior	Shallow	5.08, 5.36
5, 6	Generic Plastic	Shallow	3.03, 3.34
7, 8	Metal Slinky	Steep	4.67, 4.95
9, 10	Slinky Junior	Steep	4.23, 4.98
11,12	Generic Plastic	Steep	3.58, 4.50

A general factorial design (replicated) on spring toys.

- *continued from page 1*

test plan. The 12 results are shown sorted by standard order in the table on page 1.

The response is time in seconds for the springs to walk a four-foot inclined plank. The difference in time reflects the variations due to setting of the board, placement of the coil, how the



operator made it move, and so forth. Analysis of variance (ANOVA) from new Design-Ease® version 6 software revealed an unexpectedly large interaction (see graph).

The two Slinky-brand springs behaved as expected by walking significantly faster down the steeper incline (B+). However, just the opposite occurred with the generic plastic spring (note the reversal on the right side of the plot). It was observed taking unusually long, but low steps down the shallow slope. It didn't look very elegant, but it was what I call "sneaky" fast. On the steep slope the generic spring did the more pleasing, but slower and shorter, high-step like the Slinky toys.

After a few more years of research, I expect to be ready for my trip to the Himalayas. (I wonder if Richard James envisioned people going to the ends of the earth for Slinky treks? Being an engineer, he might've guessed that others like him would also become unraveled by these coiled springs.)

– Mark@StatEase.com

Notes from the editor:

- *The material presented in this column was taken in part from* "DOE Simplified: Practical Tools for Effective Experimentation" *by Mark J. Anderson and Patrick J. Whitcomb, ©2000, Productivity, Inc. Order this book with the enclosed order form or call Stat-Ease.*

- *The Slinky experiment is presented in detail at the new one-day "DOE Simplified" presentation, coming to a location near you. Refer to the Workshop Schedule on the front page and the story on page 4 for details.*

- *Also, see a related article, DX6 Offers General Factorials, by consultant Shari Kraber, published in the June issue of the Stat-Teaser (page 2). If you missed this, go to www.statease.com and download it there.*

DOE Conf. Proceedings Available

Were you interested, but unable, to attend the 2000 DOE Conference due to time or money constraints? If so, you'll be happy to know that copies of the conference proceedings are available for $50. Included in the proceedings are Track A (beginning) and Track B (advanced) sessions, case study presentations and the keynote speech. To order, call Renee at 800.801.7191.

The 2000 DOE Conference, (Minneapolis, MN, July 27–28), held something for everyone. Sessions for the DOE novice as well as the advanced experimenter were well received. Case study presentations were very interesting and varied. They ran from making the ideal green bean casserole recipe, to using DOE in the courtroom, to the search for optimum antibiotic production.

Scheduled keynote speaker, Douglas Montgomery, Ph.D., was unfortunately forced to cancel at the last moment. However, we got an excellent replacement speaker in Robert Mitchell, quality manager at 3M Co. and past chair of the ASQ Statistics Division, who spoke on "Using the Power of Statistical Thinking". The 2000 DOE Conference was a great success. We hope to see *you* at the next one!

Where can you find us?

September 8–10 — Industrial Statistics in Action 2000

International Conference, University of Newcastle

"How to Design & Analyze Mixture Designs that Include Process Factors and/or Categorical Factors"

by Mark Anderson, (September 9, 11:30 am)

October 12–13 — Fall Technical Conference, Minneapolis, MN

"A Unified Approach to Power Calculations for Designed Experiments"

by Gary Oehlert & Pat Whitcomb

V6 Tricks with Design-Ease & Design-Expert
Analyze a Split-Plot, Two-Level Factorial Design

Version 6 of Design-Expert® and Design-Ease software allows users to designate model terms they wish to include in their analysis of variance. Excluded terms can be ignored or used as error. This new feature makes it possible to analyze designs with restrictions in randomization, such as split-plot or nested structures. (See the section on "General Factorials" *in the software user guides.) We've recently come up with an innovative application of Design-Expert or Design-Ease: split-plot, two-level factorial design. New buyers of Stat-Ease® V6 software will find a write-up on this at the end of the* "Program Tips" *section. If you don't find this in your user guide, go to the download page on the Stat-Ease web site (www.statease.com) for the latest revisions to the documentation. Below you will find a brief overview of this new application of Stat-Ease software.*

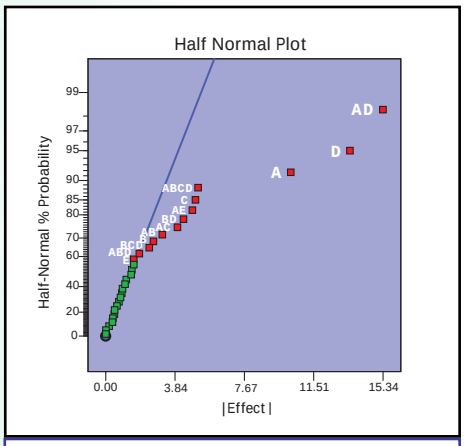
Very often, experimenters set up two-level factorial designs with the best intentions of running them in random order, but they find that a given factor, such as temperature, cannot be easily changed. In this case, the analysis should be done by the split-plot method. For the special case of two-level factorial design, Stat-Ease software's half-normal plots for effect selection can be adapted to deal with the split-plot structure. Let's see how this applies to a plasma treatment process aimed at making paper more susceptible to ink [Box, Bisgaard, et. al., "Quality Quandries: Two-Level Factorials Run as Split-Plot Experiments," *Quality Engineering*, 8(4), 705–708 (1996)]. To save time, the experimenters set up their plasma reactor at the conditions specified by factors A through D (randomized), and then processed the two paper types (E) together. (The actual placement of paper in the reactor, right versus left, was randomized by a flip of a coin.) This forms a split-plot design, broken down as follows:

- Whole-plot factors — A through D (and associated interactions)
- Sub-plot factor: E (and any interactions involving this factor)

The trick is to keep these groups separate for the analysis of variance, because the residual errors differ. Design-Ease and Design-Expert make this very easy, as documented in the latest revision to the user guide, "Program Tips". There you will find the details on how to produce the half-normal plots illustrated below.

The interaction AE stands out. Look at the bottom axis of this graph versus the one done for the whole-plot effects. Notice that the range is several-fold less for the sub-plot effects. This reflects the comparatively high variance between repeated whole-plot reactor setups (factors A through D) versus the variance within the sub-plot factor (changing paper type E).

The big question is, would the apparently significant effect of AE be obscured if the experimenters didn't recognize the split-plot structure of their design? Let's look at the original (default) half-normal plot. From the plot shown below, you can see that the sub-plot effect of AE is obscured by the variance between reactor setups (the whole plot)! Notice the split structure of the unchosen points at the left of the graph (the small effects). This reflects the dual error

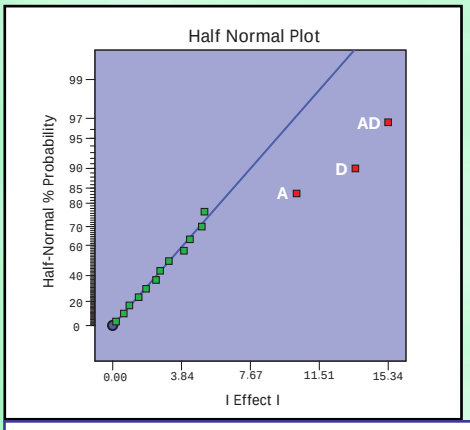


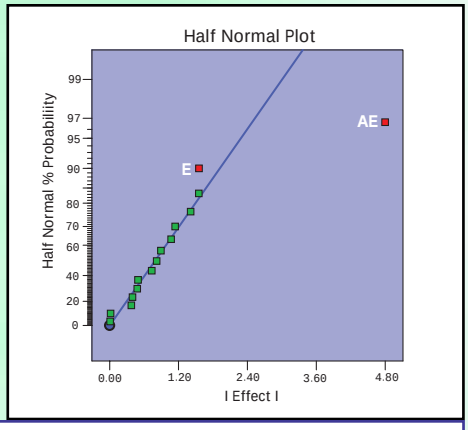
Obscured AE Interaction

structure of the split-plot design. The AE effect is buried in the error terms of the whole plot (factors A through D). The points below (to the left) of the one labeled E are mostly sub-plot effects (interactions involving factor E), which exhibit less variance (a steeper slope).

The manipulation of effect plots in this split-plot case uncovered a small but significant interaction that otherwise would've been obscured. In all likelihood, overlooking this effect makes little difference from a practical perspective, because the big breakthrough effects (AD, A, D) are revealed in either analysis.

—Mark J. Anderson & Pat J. Whitcomb





Half-Normal Plot of Whole-Plot (left) vs. Sub-Plot (right, with E picked) Effects

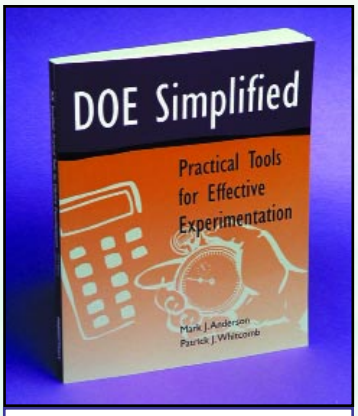
New Workshop Offered - DOE Simplified

Stat-Ease is offering a new one-day workshop, ***DOE Simplified – An Intro to Breakthrough Tools for Planned Experimentation*** (based on the *DOE Simplified* book). This workshop offers the perfect introduction to DOE for everyone from technicians to engineers to managers. It provides an overview of DOE concepts and illustrates an array of tools and design types. Although this workshop is not a substitute for hands-on computer- intensive training, it provides an educational starting point. This workshop will be one of the keys to successfully implementing designed experiments in your business.

The morning session introduces basic concepts of DOE and then explores full factorials, interactions, fractional factorials, and aliasing. Several fun, but informative, case studies from the book will be reviewed, such as making microwave popcorn and starting a reluctant weed whacker. With this session we hope to inspire you to give DOE a try, and/or to follow-up with further training.

The afternoon session looks into how to apply general factorials, response surface designs, and mixture designs. Once again, the material will be presented in an easy-to-digest, light and humorous manner, with fun case studies on slinky spring toys, teeny jelly beanies, and the like. During this session, participants will learn to appreciate all that DOE can do to find their sweet spot (the ideal settings for process factors and/or recipes for mixture components). However, don't expect to master these powerful tools without further education.

Watch for this workshop to come to a location near you, starting with Dallas, TX and Atlanta, GA in November. Check our web site at www.statease.com for the 2001 schedule. This one-day workshop is a bargain at only $295. Send four or more students and the price drops to $195 each. Participants will receive the book, *DOE Simplified*, which includes a fully-functional, time-limited copy of Design-Ease software, version 6.



The book, *DOE Simplified*, is available for $39.95 from Stat-Ease, Inc.

Contact Sherry at 612.378.9449 x18 for in-house workshop pricing information. (Or e-mail sherry@statease.com.)

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Use this form to purchase Design-Ease 6.0, Design-Expert 6.0, or the book, *DOE Simplified*.

Design-Ease 6.0 (NEW!) - Stat-Ease's newest experimental design software is the right choice for experimenters who are new to DOE or for those wishing to use DOE for screening purposes. A major upgrade, Design-Ease 6.0 offers many new features including general (multilevel) factorial designs, optimal blocking choices for standard two-level full and fractional factorials, annotated ANOVA to help with interpretation, Box-Cox plots for choosing the best transformations, and an extensive context-sensitive help system. For more information, contact Stat-Ease at 800.801.7191. Order by November 1, 2000 and receive FREE a colorful Stat-Ease mousepad!

Design-Expert 6.0 - Stat-Ease's new experimental design software advances DOE analysis functionality and ease to a new level. It represents a significant improvement over previous versions and competitive packages. Offer extended—order by November 1, 2000 and receive FREE a colorful Stat-Ease mousepad!

***DOE Simplified* Book** - A lively presentation of the basic concepts behind designed experiments. Directed at the newcomer with little or no previous experience. The book comes with a 180-day, time-limited CD-ROM of Design-Ease 6.

International Readers (Non-North American)—Important News, Please Read!

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	Upgrade to DX6 from any version of DE	Old Serial # required:	$595.00	
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